

REMARKS

Applicant's attorney acknowledges the teleconference on January 1, 2002, with Examiner Olsen regarding a restriction requirement. Applicant's attorney confirms the election of Claims 1 - 24 for prosecution, with Claims 25 and 28 being withdrawn under the restriction requirement. Applicant's attorney further confirms the election of single-crystal silicon as the substrate species, with the understanding that if a generic claim is allowed, the Examiner will consider the allowance of claims to other substrate species.

The drawings are objected to as failing to comply with 37 CFR § 1.84(p)(4), because reference numeral 110 has been used to designate both the bottom of the shaped opening and the shaped cavity. The specification has been amended at various locations to refer to the shaped cavity using reference numeral 112. In addition, Figure 1D has been amended to designate the shaped cavity using reference numeral 112. Enclosed is a marked-up, amended Figure 1D showing the amendment in red.

The drawings are objected to as failing to comply with 37 CFR § 1.84(p)(5), because they do not include reference numeral 412, which is referred to at page 21, line 25, of applicant's specification, as being an etching chamber. Enclosed is a marked-up, amended Figure 4, showing the etch chamber designated (in red) by reference numeral 412.

Enclosed are proposed formal drawings, incorporating the changes to Figures 1D and 4 discussed above. If the Examiner approves of the amendments to the drawings, the Examiner is respectfully requested to replace the originally filed informal drawings with the five (5) sheets of formal drawings submitted herewith.

The disclosure is objected to for various informalities. The informalities in the specification, which are discussed in detail on page 5 of the present Office Action, have been corrected by the amendments to the specification set forth above.

The claims are objected to as failing to comply with 37 CFR § 1.126, which requires that the original numbering of the claims be preserved throughout prosecution. In particular, Claim 26 was misnumbered as Claim 28. The Examiner is hereby requested to renumber Claim 28 as Claim 26; however, applicant has not amended originally misnumbered Claim 28, as this claim is withdrawn from prosecution.

Claim Rejections Under 37 CFR § 112

Claims 10 and 24 are rejected under 37 CFR § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In particular, the Examiner points out that it is not clear what the term “silicon” is intended by applicant to mean. Claims 10 and 24 have been amended, as set forth above, to recite that the substrate is “single-crystal silicon”, as distinguished from polysilicon, which is referred to by applicant in her specification as distinct from silicon.

In light of the amendments to Claims 10 and 24, applicant respectfully requests withdrawal of the rejection of Claims 10 and 24 under 37 CFR § 112, second paragraph.

Claim 23 is rejected under 37 CFR § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In particular, the Examiner notes that Claim 23 recites “wherein said method includes performing the following steps prior to etching said shaped cavity”, and that the continuing list of process steps recited includes limitations that are directed to the actual etching of the shaped cavity. Claim 23 has been amended, as set forth above, to remove the limitations that are directed to the actual etching of the shaped cavity.

In light of the amendment to Claim 23, applicant respectfully requests withdrawal of the rejection of Claim 23 under 37 CFR § 112, second paragraph.

Claim Rejections Under 35 USC § 102

Claims 1 - 4, 10, and 13 - 16 are rejected under 35 USC § 102(e) as being anticipated by U.S. Patent No. 5,891,807, to Muller et al.

In order to expedite the allowance of the subject application, Claims 1 - 4 have been cancelled without prejudice. Claim 6 has been amended to include non-conflicting recitations from Claims 2 and 3, since Claim 6 depended directly from Claim 3 and indirectly from Claim 2. Claim 10 and Claims 13 - 16 have been amended to depend from Claims 6 and 8 which have been amended to a format which has been indicated to be allowable.

In light of the cancellation of Claims 1 - 4 without prejudice, and the amendment of Claims 10 and 13 - 16 to depend from amended Claims 6 and 8 which are now believed to be allowable, applicant respectfully requests withdrawal of the rejection of Claims 1 - 4, 10, and 13 - 16 under 35 USC § 102(e), over Muller et al.

Claims 5 - 9, 11, and 12 are objected to as being dependent upon a rejected base claim, but are indicated to be allowable if rewritten in independent form, including all of the limitations of the base claim and any intervening claims. Claims 23 and 24 are said to be allowable if rewritten so as to overcome their respective rejections under 35 USC § 112, second paragraph, and also to include all of the limitations of the base claim and any intervening claims.

Claim 5 has been amended to include the recitations of Claim 2, from which it depended, but in a simpler format. Claim 6 has been amended as described above to include non-conflicting recitations from Claims 2 and 3, as required. Claim 7 has been amended to depend from Claim 6, Claim 8 depends from amended Claim 6, and Claim 9 has been amended to depend from Claim 8.

In view of the above, Claims 5 - 9 should be allowable.

Claim 11 is said to be allowable if rewritten in independent form. Claim 11 has been cancelled, as this claim has been rewritten in independent form as Claim 35, from which a series

of claims depend. This claim was cancelled solely to make it easier to see how the claims relate to each other. Claim 11 should be in allowable format as Claim 35.

Claim 12 has been amended to depend from Claim 10; Claim 13 has been amended to depend from Claim 6 or Claim 8; and Claim 14 has been amended to depend from Claim 13. Claims 10, 6, and 8 should be in allowable form for the reasons presented above.

New Claims 27 - 53 have been added. New Claims 27 - 34 have been added to depend from amended Claim 5, which should be allowable in its amended format. The dependent claims were previously present as multiple dependent claims which depended from Claim 5, where Claim 5 has been cancelled from the multiple dependent claims in the amended claim set. This necessitated rewriting of these dependent claims. New independent Claim 35 incorporates the features of original Claims 2, 10, and 11. Claims 36 - 46 depend from Claim 35, and incorporate various features of the original claim set.

Claim 23 is said to be allowable if rewritten so as to overcome the rejection under 35 USC § 112, second paragraph, and to include the limitations of the base claim and any intervening claims. Claim 23 has been amended to overcome the rejection under 35 USC § 112, as set forth above. Applicant wishes to present a new set of claims which are based on Claim 23 (but which do not include the features of Claim 5). New Claims 47 - 53 have therefore been added. New independent Claim 47 incorporates the features of original Claims 2 and 23. Claims 48 - 53 depend from Claim 47, and incorporate various features of the original claim set.


Applicant believes that the amendments to the claims and the new claims set forth above are fully supported by applicant's originally filed specification, claims, and drawings, and are within the subject matter the Examiner has indicated to be allowable.

Applicant would like to mention that the amendments to the claims set forth above are made solely for the purpose of expediting the allowance of the present application. Applicant will address the distinctions between other claimed subject matter and the Muller et al. reference in a subsequent continuation application.

Applicant asserts that all presently pending claims are in condition for allowance, and the Examiner is respectfully requested to pass the application to allowance.

The Examiner is invited to contact applicant's attorney with any questions or suggestions, at the telephone number provided below.

Respectfully Submitted,


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AMENDMENT "A" UNDER 37 CFR § 1.111
VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The paragraph at page 5, lines 6 - 8, has been amended as follows.

Figure 1C shows the structure of Figure 1B after the protective layer has been anisotropically etched to remove a portion of the protective layer which overlies the bottom [108] 110 of shaped opening 104.

The paragraph at page 5, lines 9 - 13, has been amended as follows.

Figure 1D shows the structure of Figure 1C after the underlying substrate 102 has been etched using the multi-step etch method of the invention to form a shaped cavity [110] 112 which underlies shaped opening 104. The shaped cavity [110] 112 is etched to have a width B and a depth C, where the width B is equal to or greater than the depth C. In particular, here, width B is equal to depth C, so that the shaped cavity [110] 112 is formed in a round, as shown.

The paragraph at page 15, lines 18 - 20, has been amended as follows.

Referring to Figure 1C, the protective layer 106 may be anisotropically etched to remove portions of the protective layer which overlie the bottom [108] 110 of the shaped opening 104. Anisotropic etching is performed using apparatus and techniques known in the art.

The paragraph at page 19, lines 4 - 12, has been amended as follows.

Figure 1D shows the structure of Figure 1C after etching of shaped cavity [110] 112 using the method of the invention. The shaped cavity [110] 112 is etched to have a width B and a depth C, where the width B is equal to or greater than the depth C. As shown in Figure 1D, the shaped cavity [110] 112 directly underlies and is in continuous communication with the shaped opening

104. The protective layer 106 effectively preserves the profile of the shaped opening 104 during etching of the underlying shaped cavity [106] 112 using the method of the invention. The shaped cavity [110] 112 shown in Figure 1D has been etched so that the width B is approximately equal to the depth C, resulting in the formation of a substantially round shaped cavity.

The paragraph at page 21, line 20, through page 22, line 6, has been amended as follows.

Preferably, the apparatus used to practice the present invention is adapted to be controlled by a computer. Figure 4 shows a computer 400. Computer 400 comprises a processor 402, memory 404 adapted to store instructions 406, and one or more ports 408. Processor 402 is adapted to communicate with memory 404 and to execute instructions 406. Processor 402 and memory 404 are also adapted to communicate with one or more ports 408. Ports 408 are adapted to communicate with an etch chamber 412. Chamber 412 is adapted to carry out process steps in accordance with signals received from processor 402 via ports 408. Preferably, computer [402] 400 can control the composition and feed rate of the etch process feed gases, the process temperature, the pressure in the chamber, the time period for each process step, and other similar functions. Preferably, computer [402] 400 is adapted to receive measurements that describe the conditions in the chamber or a condition of the substrate being etched, and adapt the process variables accordingly. This programmed control of process variables enables production of a predetermined device etch profile as required for a given use application.

IN THE CLAIMS:

Claims 1 - 4 and 11 have been cancelled without prejudice.

Claims 5 - 7, 9, 10, 12, 13, 23, and 24 have been amended as follows.

New Claims 27 - 53 have been added.

5. (Once Amended) A method of etching a shaped cavity in a substrate, wherein initial etching of said shaped cavity is performed using an initial process chamber pressure, wherein continued etching of the shaped cavity is performed using a process chamber pressure that is at least 25% lower than said initial process chamber pressure, and wherein etching of said shaped cavity is followed by [The method of Claim 2, wherein said method further comprises] an etch finishing step, wherein said etch finishing step is performed using a process chamber pressure that is within a range of about 80% to about 100% of said initial process chamber pressure.

6. (Once Amended) A method of etching a shaped cavity in a substrate, wherein the method comprises:

a) an initial cavity etch step during which said substrate is etched to form a shaped cavity using an initial process chamber pressure;

b) at least one additional etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is within a range of about 25 % to about 50 % lower than said initial process chamber pressure; and

c) [The method of Claim 3, wherein said method further comprises a third etch step] an additional etch step following step b), during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 40 % lower than the process chamber pressure used during the performance of [said second etch step] step b).

7. (Once Amended) The method of Claim 6, wherein [said third] etch step c) is performed using a process chamber pressure that is within a range of about 40% to about 50% lower than the process chamber pressure used during the performance of step b).

9. (Once Amended) The method of [Claim 5 or] Claim 8, wherein said etch finishing step is performed using a process chamber pressure that is about 90% of said initial process chamber pressure.
10. (Once Amended) The method of [Claim 2 or Claim 5, or] Claim 6, or Claim 8, wherein said substrate comprises single-crystal silicon, and etching is performed using a plasma containing reactive fluorine species.
12. (Once Amended) The method of Claim [11] 10, wherein said plasma source gas further comprises an additive gas selected from the group consisting of O₂, HBr, Cl₂, N₂, and combinations thereof.
13. (Once Amended) The method of [Claim 2 or Claim 5 or] Claim 6 or Claim 8, wherein etching is performed using a plasma generated from a source gas comprising a gas selected from the group consisting of SF₆, CF₄, Cl₂, HBr, and combinations thereof.
14. (Once Amended) The method of Claim 13, wherein said plasma source gas further comprises an additive gas selected from the group consisting of Ar, O₂, [HBr, Cl₂,] N₂, and combinations thereof, wherein said additive gas is provided in an amount sufficient to improve profile control during etching.
23. (Once Amended) The method of [Claim 2 or Claim 5 or] Claim 6 or Claim 8, wherein said method includes performing the following steps prior to said initial cavity etch step: etching said substrate to a predetermined depth to form a shaped opening, then forming a conformal protective layer overlying at least a sidewall of said shaped opening, wherein said protective layer comprises

a material having a different etch selectivity than said substrate [, wherein said shaped cavity is etched so that said shaped cavity directly underlies and is in continuous communication with said shaped opening, and wherein said shaped cavity is etched using an etchant gas which selectively etches said substrate relative to said protective layer, whereby said protective layer effectively preserves the profile of said shaped opening during etching of said shaped cavity].

24. (Once Amended) The method of Claim 23, wherein said substrate comprises single-crystal silicon and said protective layer comprises silicon oxide.

27. (New) The method of Claim 5, wherein said substrate comprises single-crystal silicon, and etching is performed using a plasma containing reactive fluorine species.

28. (New) The method of Claim 27, wherein said plasma source gas further comprises an additive gas selected from the group consisting of O₂, HBr, Cl₂, N₂, and combinations thereof.

29. (New) The method of Claim 5, wherein etching is performed using a plasma generated from a source gas comprising a gas selected from the group consisting of SF₆, CF₄, Cl₂, HBr, and combinations thereof.

30. (New) The method of Claim 29, wherein said plasma source gas further comprises an additive gas selected from the group consisting of Ar, O₂, N₂, and combinations thereof, wherein said additive gas is provided in an amount sufficient to improve profile control during etching.

31. (New) The method of Claim 29, wherein said plasma source gas further comprises an essentially nonreactive, diluent gas selected from the group consisting of He and Xe.

32. (New) The method of Claim 30, wherein said plasma source gas further comprises an essentially nonreactive, diluent gas selected from the group consisting of He and Xe.

33. (New) The method of Claim 5, wherein said method includes performing the following steps prior to said initial cavity etch step: etching said substrate to a predetermined depth to form a shaped opening, then forming a conformal protective layer overlying at least a sidewall of said shaped opening, wherein said protective layer comprises a material having a different etch selectivity than said substrate.

34. (New) The method of Claim 33, wherein said substrate comprises single-crystal silicon and said protective layer comprises silicon oxide.

35. (New) A method of etching a shaped cavity in a substrate, wherein the method comprises:
a) an initial cavity etch step during which said substrate is etched to form a shaped cavity using an initial process chamber pressure; and

b) at least one additional etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 25% lower than said initial process chamber pressure,

wherein said substrate comprises single-crystal silicon, and wherein etching is performed using a plasma generated from a source gas comprising SF₆ and Ar.

36. (New) The method of Claim 35, wherein said at least one additional etch step includes a second etch step which is performed using a process chamber pressure that is within a range of about 30% to about 50% lower than said initial process chamber pressure.

37. (New) The method of Claim 36, wherein said second etch step is performed using a process chamber pressure that is about 30% lower than said initial process chamber pressure.
38. (New) The method of Claim 37, wherein said at least one additional etch step further includes a third etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 40% lower than the process chamber pressure used during the performance of said second etch step.
39. (New) The method of Claim 38, wherein said third etch step is performed using a process chamber pressure that is within a range of about 40% to about 50% lower than the process chamber pressure used during the performance of step b).
40. (New) The method of Claim 35 or Claim 36 or Claim 39, wherein, subsequent to said at least one additional etch step, an etch finishing step is performed using a process chamber pressure that is within a range of about 80% to about 100% of said initial process chamber pressure.
41. (New) The method of Claim 40, wherein said etch finishing step is performed using a process chamber pressure that is about 90% of said initial process chamber pressure.
42. (New) The method of Claim 35, wherein said plasma source gas further comprises an additive gas selected from the group consisting of O₂, HBr, Cl₂, N₂, and combinations thereof.
43. (New) The method of Claim 35, wherein said plasma source gas further comprises an additive gas selected from the group consisting of Ar, O₂, HBr, Cl₂, N₂, and combinations thereof,

wherein said additive gas is provided in an amount sufficient to improve profile control during etching.

44. (New) The method of Claim 35 or Claim 42 or Claim 43, wherein said plasma source gas further comprises an essentially nonreactive, diluent gas selected from the group consisting of He and Xe.

45. (New) The method of Claim 35, wherein said method includes performing the following steps prior to said initial cavity etch step: etching said substrate to a predetermined depth to form a shaped opening, then forming a conformal protective layer overlying at least a sidewall of said shaped opening, wherein said protective layer comprises a material having a different etch selectivity than said substrate.

46. (New) The method of Claim 45, wherein said protective layer comprises silicon oxide.

47. (New) A method of etching a shaped cavity in a substrate, wherein the method comprises:
a) etching said substrate to a predetermined depth to form a shaped opening;
b) forming a conformal protective layer overlying at least a sidewall of said shaped opening, wherein said protective layer comprises a material having a different etch selectivity than said substrate;

c) an initial cavity etch step during which said substrate is etched to form a shaped cavity using an initial process chamber pressure; and

d) at least one additional etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 25% lower than said initial process chamber pressure.

48. (New) The method of Claim 47, wherein said at least one additional etch step includes a second etch step which is performed using a process chamber pressure that is within a range of about 30% to about 50% lower than said initial process chamber pressure.

49. (New) The method of Claim 48, wherein said second etch is performed using a process chamber pressure that is about 30% lower than said initial process chamber pressure.

50. (New) The method of Claim 48, wherein said at least one additional etch step further includes a third etch step during which continued etching of said shaped cavity is performed using a process chamber pressure that is at least 40% lower than the process chamber pressure used during the performance of said second etch step.

51. (New) The method of Claim 50, wherein said third etch step is performed using a process chamber pressure that is within a range of about 40% to about 50% lower than the process chamber pressure used during the performance of step d).

52. (New) The method of Claim 47 or Claim 48 or Claim 50, wherein, subsequent to said at least one additional etch step, an etch finishing step is performed using a process chamber pressure that is within a range of about 80% to about 100% of said initial process chamber pressure.

53. (New) The method of Claim 52, wherein said etch finishing step is performed using a process chamber pressure that is about 90% of said initial process chamber pressure.